

Baryons made of heavy quarks at the LHC

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Baryons made of heavy quarks are extremely interesting and could be seen at the LHC.

This is a short report on baryons made of heavy quarks, i.e. t, b, c and s, a work which was initiated in discussions with Jean-Marc Richard and Tai Tsun Wu. It happens that nothing of this work was ever published, except for the fact that Jean-Marc Richard touched that subject in a recent talk at a workshop organized by LHCb. So, I decided to write something myself, though I owe a lot to Jean-Marc and Tai.

The extraordinarily large luminosity of the LHC makes it possible to see particle systems whose creation is not very likely and which are extremely interesting. To begin I start with the fact that the belief that the top quark never hadronizes can be challenged. Indeed, out of 20 million top quarks, 1000 of them have life which is 10 times the official lifetime and have time to hadronize. How? I don't want to fight with my colleagues, but if one could see, for instance, tbb it would be fantastic! To be more realistic we concentrate on baryons made of b, c, and s quarks. In particular the dream of Björken to see a ccc baryon becomes accessible, but you can see more than that, like the bbb baryon. The masses of these particles can be calculated using a potential model proposed by Jean-Marc Richard in 1981 [1], inspired by a potential that I had proposed earlier for mesons [2]. These potentials, even though there is hardly a good justification for them, are extremely successful. for instance they

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give the mass of the Ω^- with an accuracy of 0.2% or the mass of the B_s with an accuracy such that when the late Lorenzo Foà announced its discovery by Aleph he said that he did not need to give the value of the mass since I had predicted it already. As Rudolf Faustov noticed you don't need to use more sophisticated methods to get these masses.

What seems to me extremely interesting is the chain decays of these baryons. You go from one baryon to the next by emitting either a lepton pair or a meson with a change of charge of one unit, and, provided the initial baryons are produced with sufficient energy, you can see the various steps because of the relatively large lifetime of the b quarks of 1.6×10^{-12} secs. Let me take one example, which is probably not the most likely, but pedagogically simple. You can have

bbb (charge -1) \rightarrow bbu (charge 0, invisible) \rightarrow buu (charge +1) \rightarrow uuu (i.e. Δ^{++} , charge +2) \rightarrow uud (proton)

On all the visible elements of the chain, charge, mass, lifetime can be measured. The above potential model can be tested. Branching ratios can improve the information on the CKM matrix. Seen by a perhaps naïve theoretician, this seems very promising. Marek Karliner informed me that he and Jonathan Rosner have written a paper on Baryons containing 2 heavy quarks [3].

[1] J.-M. Richard, Phys. Lett. **B100**, 515(1981).

[2] A. Martin, Phys. Lett. **B100**, 511(1981). See also A. Martin, arXiv:0705.2353v1 (hep-ph) 15 May 2007.

[3] M. Karliner and J. Rosner, arXiv:1408.5877 (hep-ph) 25 August 2014.